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HOG FUEL DRYING: STATUS OF EXISTING SYSTEMS IN THE CANADIAN PULP AND PAPER INDUSTRY

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OBJECTIVES:

- To identify the current operating conditions of hog fuel drying systems.
- To find out what the most serious operating and maintenance problems are.
- To comment on the future applications of these systems

RESULTS:

- Three of five systems operating at less than design capacity on a continuing basis.
- One system (flash drying) operating at or above capacity.
- Serious corrosion problems in British Columbia units due to salt content in hog fuel.
- Many auxiliary equipment problems following initial startup.

CONCLUSIONS:

- Direct contact drying of hog fuel is technically viable.
- Most systems would not be economically viable at current fossil fuel prices.
- More attention must be given to the selection of materials for fabrication of equipment to resist corrosion and to the design of the material handling systems.
- Suspension firing of dried hog fuel may have the greatest potential for future applications.

RECOMMENDATIONS/ COMMENTS

- A detailed analysis of the total energy savings of the combination of a boiler and hog fuel dryer should be made and compared with a modern boiler designed for firing moist hog fuel.
- Other methods of economically dewatering hog fuels to practical levels should be investigated.

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Hog Fuel Drying

Status of Existing Systems

in the

Canadian Pulp and Paper Industry

Index

		PAGE
EXECUTIVE SUMMARY		ii
1.	Introduction	1
	1.1 Background	1
	1.2 Purpose of Study	2
	1.3 Types of Direct Contact Hog Fuel Dryers	3
	1.4 Hog Fuel Dryer Installations	4
2.	Rotary Dryers	7
	2.1 MacMillan Bloedel Limited, Powell River, British Columbia	7
	2.2 Scott Maritimes Limited, New Glasgow, Nova Scotia	10
	2.3 Great Lakes Forest Products Limited, Thunder Bay, Ontario	12
3.	Cascade Dryers	14
	3.1 British Columbia Forest Products Limited, Crofton, British Columbia	14
4.	Flash Dryers	18
	4.1 E.B. Eddy Forest Products Limited, Espanola, Ontario	18
5.	Summary and Conclusion	21
	5.1 Dryer Performance	21
	5.2 Operating Benefits	21
	5.3 Operating Problems	22
	5.4 Maintenance Problems	24

Appendix

1. Bibliography
2. Abbreviations, Glossary of Terms
3. Flow Diagrams
4. Field Notes

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Hog Fuel Drying
Status of Existing Systems
in the
Canadian Pulp and Paper Industry

Executive Summary

1. Introduction

The Canadian pulp and paper industry is a major user of fossil fuels. Pulp and paper mills and the sawmills that supply wood fiber to them, produce a large quantity of bark and wood residues that can be substituted for fossil fuels.

Several manufacturing firms have developed hog fuel drying systems which utilized boiler flue gas in direct contact with the hog fuel to reduce the moisture content of the fuel prior to its introduction into the boiler combustion chamber. The purpose of the dryers is to stabilize combustion, improve load response and either increase the hog fuel burning capacity of existing boilers or reduce the capital cost of new boilers.

Three types of direct contact dryers have been installed in Canadian pulp and paper mills. These consisted of three rotary drying systems, one cascade system and one flash dryer system. As part of its renewable energy programs, the Government of Canada provided incentive funding for four of these systems.

2. Purpose of Study

The purpose of this study is to:

- review the actual experience with each of these types of hog fuel drying systems
- determine what the most serious problems are from an operating and maintenance point of view and their affects on the present and future viability of these systems.

A detailed economic evaluation of these systems was not part of the scope of this study.

Executive Summary

3. Dryer Performance and Operating Benefits

All of the hog fuel drying systems described in this study have demonstrated that they are capable of operating at capacities and moisture reductions which meet their original design criteria. However, most of the systems are operating at average capacities that are less than the original design rates. The lower operating rates are caused by limitations in the total systems and not necessarily by the dryers themselves.

All of the systems have produced significant benefits in terms of improved boiler operation and increased hog fuel burning capacity, but only one of the four systems for which data was available, reported that the expected fossil fuel savings were achieved. Two mills have achieved approximately 73% of their plan while the fourth has achieved only 41%.

4. Operating Problems

All of the systems experienced operating problems during their intitial startup. Most of these problems were easily overcome and the subsequent operation of the dryers has been relativley trouble free.

The operation of the hog fuel material handling systems associated with the dryers has continued to plague one of the installations and in this case continues to cause excessive downtime.

Fires have been an occasional problem for some installations. The incidence of fires is unrelated to the type of dryer. The cause of the fires is usually related to air leakages into the flue gas stream through air heaters, and expansion joints.

5. Maintenance Problems

Corrosion of equipment fabricated from carbon steel has been a major maintenance cost factor for two mills which have salt in their hog fuel. Future systems which would use hog fuel containing salt should be designed with the appropriate metallurgy.

Equipment wear due to abrasion has been a significant cost for two of the installations. This has been related mainly to the hog fuel conveying equipment.

Executive Summary

6. Viability

6.1 Technical

Each of the dryer types is a viable technology. The dryers effectively reduce the hog fuel moisture content and significantly improve the operation of the boilers when burning hog fuel. The improvements include increased combustion capacity and load response and reduced particulate emissions.

The overall technical viability of two of the drying systems has been impaired by corrosion of system components in contact with the flue gas and by deficiencies in the material handling systems. The technical solutions to both of these problems are relatively simple. When the hog fuel contains salt, an appropriate grade of stainless steel should be used in the fabrication of equipment in contact with flue gas which is near or below the dew point. The material handling systems must be designed for continuous, long term service. This will include robust design with provisions for abrasion resistance and ease of maintenance.

Three of the four mills, for which some data was available did not achieve the total increase in hog fuel comsumption that was planned. Some, but not all, of the shortfall was due to lower than expected system availability. The reasons for the balance of the difference are not clear. One possibility is that the expected increase in combustion capacity at the lower moisture content was not realized. Another possibility is that other energy conservation changes reduced steam the demand from the boiler.

6.2 Economics

The economics of hog fuel drying will vary with each specific site. Although detailed economic evaluations of the existing drying systems were not available, it would appear that many of the systems did not achieve the cost savings that were originally planned. Three of the five sites provided some data on fossil fuel savings. This data indicates that the average fuel savings for each of these sites were 41%, 73%, and 75% respectively. On this basis it is unlikely that these systems would have been installed if these lower fuel savings were known at the time of making the decision to proceed.

Two of the sites experienced higher than expected maintenance costs to overcome corrosion in the equipment and to upgrade the material handling systems. These additional costs further detracted from the economic benefits of the dryers. If these sites had used more expensive metallurgy and higher quality material handling systems in the initial construction it would have cost less than it did to upgrade the systems after startup. However, it is possible that these higher initial costs would have made the systems uneconomical.

7. Future Applications

Hog fuel drying systems should be considered whenever increased hog fuel burning capacity is required for an existing boiler. However the high capital cost of these systems will generally limit their application to periods when fossil fuel prices are much higher than the current price of approximately $19 per barrel. There are two specific applications were dryers may be justified when fossil fuel prices are only slightly above the current one. They are:

(1) Hog fuels which cannot be mechanically dewatered to less than 64% M.C. due to the presence of snow and ice or because of limitations in the mechanical dewatering equipment will require auxilliary fossil fuel firing to maintain stable combustion. In this case, thermal drying may be justified as the only means of disposing of the hog fuel in an economic manner. This would be the case if landfilling and its associated environmental costs are a significant cost factor.

(2) Suspension burning of the fines fraction of the dried hog fuel appears to provide the greatest improvements in the boiler operation. One of the mills that initially proceeded with burning on the boiler grate has modified their system by separating the dried fines from the hog fuel and have added a suspension burner to the boiler. Another of the mills is considering this option. The mill that used suspension burning for their initial system is the only one that reported that their fuel savings exceeded the plan. However, the documentation of this saving was not provided.

It is possible that a small scale hog fuel dryer that is used for drying and suspension burning of only the fine fraction of the hog fuel would be an economically viable option at today's fossil fuel prices.

NEILL AND GUNTER LIMITED

Hog Fuel Drying

Status of Existing Systems

in the

Canadian Pulp and Paper Industry

1. Introduction

1.1 Background

The Canadian pulp and paper industry consumes approximately 89,800,000 cubic meters per year of wood fiber [1] to manufacture a variety of pulp and paper products. One of the first stages in the manufacturing process is the removal of bark from the wood. The debarking process may be performed at the pulp or paper mill or at sawmills which supply chips to these mills. Approximately 13,600,000 Bone Dry tonnes per year of bark and wood residues are produced from the wood that is used for pulp and paper manufacturing. These residues are commonly referred to as hog fuel and for years they were considered a nuisance which had to be disposed of in the lowest cost manner possible.

Pulp and paper mills require large amounts of heat energy for their production processes. Hog fuel is often used as a source of fuel for supplying a portion of these heat energy needs. However, a 1975 survey[2] showed that, while 70% of the bark produced at the pulp and paper mill site was used for fuel, only 45% of all bark produced by pulp and paper mills and sawmills was used in this manner. The balance was disposed of through landfilling or incineration. The low utilization of available hog fuel was due to the fact that alternate fuels such as oil and gas were relatively inexpensive and hog fuel burning efficiencies were low. With the start of the oil supply and price "crisis" in 1973, hog fuel became a more attractive energy source. At the same time the Government of Canada initiated programs to reduce our dependance on non-renewable fossil fuels. The increased cost of fossil fuels and Government incentives resulted in the construction of new hog fuel boilers and the upgrading of many existing systems.

1.1.1 Problems in Burning Hog Fuel

The practical use of bark and wood residues as a fuel has many problems.

(a) It is a difficult material to handle and store.
(b) Moisture contents vary widely.
(c) The ease of burning is greatly affected by the moisture content.

1. Introduction

(d) Ash handling and disposal is a problem.
(e) Stack emission control and dust collection can be expensive and troublesome.

Over the past few years there has been a great increase in the technical knowledge associated with hog fuel handling and burning. New developments in handling and burning techniques provide greater assurance of success for new installations. However, they can also add to the capital investment required to complete a successful facility.

1.1.2 Moisture in Hog Fuel

The energy available from hog fuel is a direct function of its moisture content. The moisture content of the fuel affects the boiler efficiency due to latent heat loss of the fuel moisture and it affects the boiler capacity due to the amount of water that must be evaporated and the rate at which evaporation will take place. Furnace volumes and fan sizes must be increased to handle the increased gas volumes associated with evaporated moisture.

Most industries attempt to keep moisture levels low by using dry debarking techniques and log thawing processes to remove surface ice and snow. If wet debarking is used, mechanical bark presses are justified in reducing the moisture content. Typically, moisture contents in hog fuel will average 50% to 55% (by weight - wet basis) over the year with a range from 30% to 65%, depending on handling and storing techniques.

1.2 Purpose of this Study

The drying of hog fuel, prior to its introduction into the boiler combustion chamber has been advocated as a method of stabilizing combustion, improving load response and either increasing the hog fuel burning capacity of existing boilers or reducing the capital cost of new hog fuel boilers. Three technologies for direct contact drying of hog fuels have been developed and applied to a number of hog fuel boilers in the Canadian pulp and paper industry. Most of these installations have received incentive funding from the Government of Canada as part of its renewable energy programs.

The purpose of this study is to review the actual experience with a number of these technologies and to determine what the most serious problems from an operating and maintenance point of view are and their affects on the present and future viability of these systems. The study was limited to dryers employing flue gases in direct contact with the hog fuel.

1. Introduction

1.3 Types of Direct Contact Fuel Dryers

The three types of direct contact hog fuel dryers used in the Canadian pulp and paper industry include: rotary dryers, cascade dryers and flash dryers and each is described briefly in the following paragraphs. It is assumed that the readers will already have a knowledge of the principles of operation of these dryers and the theoretical principles of their design. A complete discussion of hog fuel dryers is contained in ENFOR reports C-96[4] and C-258[5], Phase I, Volume III.

1.3.1 Rotary Dryers

Rotary dryers use a horizontal or slightly sloped rotating cylinder. Hot flue gases and moist hog fuel are fed into one end of the cylinder and flow to the opposite end. Lifters around the periphery of the cylinder provide agitation of the hog fuel and cause it to tumble through the hot flue gas flow. A portion of the fines within the hog fuel are carried out of the dryer in the flue gas. The fines are separated from the flue gas after the dryer in a series of cyclones.

1.3.2 Cascade Dryers

Cascade dryers use a vertical cylinder with a conical top and bottom. Hot flue gas is fed into the bottom of the cylinder and flows towards the top where it is deflected downwards along the outside walls. A portion of the gas exits the cylinder around the deflector. The hog fuel is dropped into the top of the cylinder near the walls, travels downward and meets the incoming flue gas and is then carried upwards to the deflector. As the hog fuel is recirculated in the cylinder a portion is drawn off through a slot in the cylinder wall.

Fines are removed from the exhaust gases in a multiple cyclone assembly.

1.3.3 Flash Dryers

In flash dryers the moist hog fuel is dropped into a stream of hot flue gas which conveys the fuel to a classifier. The classifier separates the larger particles from the flow and directs them to a hammer mill to reduce the hog fuel particle size and expose new surfaces for drying. The hammer mill discharges back into the classifier. The combined flow passes through a flash drying duct to a cyclone where the hog fuel is separated from the flue gas.

1. Introduction

1.4 Hog Fuel Dryer Installations

There are five major hog fuel drying systems installed in Canadian pulp and paper mills. These consist of three rotary dryer systems, one cascade system and one flash drying system. The basic data for each system is included in Tables 1 and 2 which follow:

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Séchage des déchets de bois utilisés comme combustible

Rapport sur la situation des systèmes existants

dans l'industrie canadienne des pâtes et papiers

Résumé

1. Introduction

L'industrie canadienne des pâtes et papiers est une grande consommatrice de combustibles fossiles. Les usines de pâtes et papiers et les scieries qui leur fournissent la fibre de bois produisent une grande quantité d'écorce et de résidus de bois qui peuvent remplacer les combustibles fossiles.

Plusieurs manufacturiers ont mis au point des systèmes de séchage des déchets de bois qui utilisent les gaz de carneaux des chaudières et les mettent en contact direct avec les déchets de bois pour réduire leur teneur en humidité avant de les introduire dans la chambre de combustion de la chaudière. Les séchoirs servent à stabiliser la combustion, améliorer la réponse à la charge et soit augmenter la capacité de combustion des déchets de bois des chaudières existantes soit diminuer les coûts d'installation de nouvelles chaudières.

Des séchoirs par contact direct de trois types différents ont été installés dans des usines de pâtes et papiers canadiennes. Il s'agit de trois systèmes de séchage rotatifs, d'un système à cascade et d'un système de séchage pneumatique. Le Gouvernement du Canada a subventionné l'installation de quatre de ces systèmes dans le cadre de ses programmes d'énergies renouvelables,

2. But de l'étude

Le but de cette étude est:

- d'examiner les résultats obtenus par l'usage de chaque type de système de séchage des déchets de bois,

- de déterminer quels sont les problèmes de fonctionnement et d'entretien les plus sérieux qui sont survenus et quels sont leurs effets sur la viabilité des systèmes à court et long terme.

Cette étude n'inclut pas l'évaluation détaillée des systèmes sur le plan économique.

Résumé

3. Rendement et avantages des séchoirs

Il a été démontré que tous les systèmes de séchage des déchets de bois décrits dans cette étude pouvaient atteindre les capacités de fonctionnement et les taux de réduction d'humidité établis lors de leur conception originale. Cependant, la majorité des systèmes sont exploités à des capacités moyennes de fonctionnement inférieure aux critères de conception. Cela est dû aux limites des systèmes en général et non pas nécessairement aux séchoirs.

Tous les systèmes se sont avérés avantageux des points de vue de l'amélioration du fonctionnement de la chaudière et de l'augmentation de la capacité de combustion des déchets de bois. Par contre, seulement un des quatre systèmes pour lesquels des données étaient disponibles a permis d'atteindre les économies prévues en combustible fossile. Deux autres systèmes ont permis d'atteindre environ 73% des économies prévues et le quatrième seulement 41%.

4. Problèmes de fonctionnement

Tous les systèmes ont connu des problèmes de fonctionnement lors de la mise en marche initiale mais la majorité ont pu être réglés facilement. Le fonctionnement ultérieur des séchoirs s'est fait presque sans problème.

Le système de manutention des déchets de bois relié à l'un des séchoirs n'a pas cessé de causer des problèmes dans une des installations et entraîne encore des arrêts fréquents.

Des incendies ont aussi causé quelques problèmes dans certaines installations mais aucun lien n'a été établi entre leur fréquence et les types de séchoirs. Ces incendies sont généralement causés par des infiltrations d'air provenant des réchauffeurs ou des joints de dilatation dans les carneaux.

5. Problèmes d'entretien

Des coûts d'entretien importants ont été occasionnés, dans deux usines, par la corrosion de certains composants en acier au carbone causée par le sel contenu dans les déchets de bois. Les nouveaux systèmes prévus pour des déchets contenant du sel devront être conçus avec des métaux appropriés.

Dans deux des installations, l'usure du matériel par l'abrasion, et plus spécialement du matériel de manutention des déchets de bois, a entraîné des coûts importants.

Résumé

6. Viabilité

6.1 Sur le plan technique

Tous les types de séchoirs font appel à des technologies viables. Ils réduisent efficacement la teneur en humidité des déchets de bois et améliorent de manière significative le fonctionnement des chaudières lors de la combustion de ces déchets. Parmi les améliorations notons l'augmentation de la capacité de combustion et de la réponse à la charge et la diminution de l'émission de particules.

Deux des systèmes de séchage ont vu leur viabilité réduite par la corrosion des composants en contact avec les gaz de carneaux et par des faiblesses dans les systèmes de manutention des matériaux. D'un point de vue technique, il serait relativement simple de régler ces problèmes. D'abord, lorsque les déchets de bois contiennent du sel, les composants qui entrent en contact avec des gaz de carneaux qui sont près ou en dessous du point de rosée devraient être fabriqués avec une catégorie appropriée d'acier inoxydable. Ensuite, les systèmes de manutention devraient être conçus en vue d'une utilisation continue et à long terme. Cela signifie qu'ils doivent être conçus solidement, avec des matériaux résistant à l'abrasion, et faciles d'entretien.

Trois des quatre usines pour lesquelles des données étaient disponibles n'ont pas atteint l'augmentation prévue dans la consommation de déchets de bois. Cela a été causé en partie par la disponibilité du système qui a été inférieure aux prévisions. Les autres causes ne sont pas claires. Il se peut que l'augmentation de la capacité de combustion prévue malgré une faible teneur en humidité n'ait pas été atteinte. Il est aussi possible que d'autres changements apportés en vue de conserver l'énergie aient réduit la demande de vapeur de la chaudière.

6.2 Sur le plan économique

L'aspect économique du séchage des déchets de bois varie d'une installation à une autre. Même si aucune évaluation économique des systèmes de séchage existants n'était disponible, il semble que plusieurs systèmes n'ont pas obtenu les réductions de coûts qui avaient été prévues. Trois des cinq usines ont fourni quelques données sur les économies de combustibles fossiles. Ces données indiquent que les économies moyennes de combustible pour chacune de ces usines sont de 41%, 73% et 75% respectivement. Il est peu probable que ces systèmes auraient été installés si, au moment de prendre la décision, ces données sur les faibles économies d'énergie avaient été connues.

Résumé

Dans deux des usines, les coûts d'entretien ont été supérieurs à ce qui avait été prévu car il a fallu lutter contre la corrosion du matériel et améliorer les systèmes de manutention des déchets. Ces coûts additionnels ont réduit les avantages des séchoirs sur le plan économique. L'emploi de métaux plus dispendieux et de systèmes de manutention de meilleure qualité lors de la construction initiale, aurait coûté moins cher que l'amélioration des systèmes après leur mise en service. Cependant, il est possible qu'avec des coûts de base plus élevés les systèmes auraient été jugés non rentables.

7. Applications futures

L'installation de systèmes de séchage des déchets de bois pourrait être avantageuse lorsque la capacité de combustion des déchets de bois d'une chaudière existante doit être augmentée. Cependant, étant donné que l'installation de tels systèmes nécessite des investissements élevés, elle est généralement limitée aux périodes où les prix des combustibles fossiles sont plus élevés que le prix actuel d'environ 19$ le baril de pétrole. Il y a deux situations précises qui peuvent justifier l'installation de séchoirs, même lorsque les prix des combustibles fossiles ne sont pas beaucoup plus élevés qu'à l'heure actuelle:

(1) Lorsque les déchets de bois ne peuvent être essorés mécaniquement pour réduire à moins de 64% leur teneur en humidité, à cause de la présence de neige et de glace ou à cause des limites des systèmes d'essorage mécanique, il faut un apport de combustible fossile pour stabiliser la combustion. Dans ces circonstances, le séchage à la chaleur peut être le seul moyen de se débarasser des déchets de bois d'une manière économique. Cela peut être aussi le cas lorsque les coûts de remblayage et les frais connexes sont un facteur économique important.

(2) La combustion en suspension des fines qui se trouvent dans les déchets de bois séchés semble beaucoup améliorer le fonctionnement des chaudières. Une des usines qui avait opté pour la combustion sur grille a modifié son système pour séparer les fines sèches des déchets de bois et a installé dans la chaudière un brûleur à suspension. Une autre usine envisage cette solution. L'usine qui à utilisé ce système de combustion en suspension est la seule qui signale une économie de combustible supérieure à ce qui avait été prévu, mais elle ne donne pas de détails.

Il est possible que l'installation d'un petit système de séchage des déchets de bois utilisé seulement pour le séchage et la combustion en suspension des fines comprises dans les déchets de bois soit une alternative économiquement viable même aux prix actuels des combustibles fossiles.

NEILL AND GUNTER LIMITED

Séchage des déchets de bois utilisés comme combustible

Rapport sur la situation des systèmes existants

dans l'industrie canadienne des pâtes et papiers

1. Introduction

1.1 Renseignements généraux

L'industrie des pâtes et papiers utilise environ 89 800 000 mètres cubes de fibre de bois par année (1) pour la fabrication de divers produits. Une des premières étapes du processus de fabrication est l'écorçage du bois, qui peut être effectué dans les usines de pâtes et papiers où dans les scieries qui fournissent les copeaux aux usines. Environ 13 600 000 tonnes anhydres d'écorces et de résidus de bois sont récupérées annuellement du bois utilisé pour la fabrication des pâtes et papiers. Pendant plusieurs années, ces déchets de bois ont été jugés inutilisables et étaient éliminés de la manière la plus économique.

Dans les usines de pâtes et papiers, toutes les étapes de production nécessitent de grandes quantités d'énergie calorifique. Les déchets de bois sont souvent utilisés pour fournir une partie de cette énergie. Une enquête menée en 1975 (2) démontrait cependant que même si 70% de l'écorce produite dans une usine de pâtes et papiers était utilisée comme combustible dans cette même usine, seulement 45% de toute l'écorce produite par les usines et les scieries servait de combustible, le reste étant soit utilisé comme matériau de remblayage soit incinéré. L'utilisation limitée des déchets de bois était justifiée par leur faible rendement et par le prix peu élevé des autres combustibles comme le mazout et le gaz. Par contre, avec l'avènement de la crise du pétrole en 1973, les déchets de bois sont devenus une source d'énergie intéressante. Au même moment, le Gouvernement du Canada mettait sur pied des programmes visant à diminuer notre dépendance en combustibles fossiles non renouvelables. L'augmentation des coûts des combustibles fossiles et les encouragements du Gouvernement ont amené la constructon de nouvelles chaudières pour la récupération des déchets de bois et la modernisation de plusieurs systèmes existants.

1.1.1 Problèmes rencontrés lors de la combustion des déchets de bois

L'utilisation de l'écorce et des résidus de bois comme combustible causent plusieurs problèmes, par exemple, au niveau:

1. Introduction

(a) de la manutention et du stockage des déchets;
(b) de la teneur en humidité qui varie beaucoup;
(c) de la teneur en humidité qui influe beaucoup sur la combustion;
(d) de la manutention des cendres et de la façon de s'en débarasser;
(e) du contrôle des fumées et du dépoussiérage qui peuvent être coûteux et compliqués.

Au cours des dernières années, grâce aux nouvelles connaissances techniques acquises dans le domaines de la manutention et de la combustion des déchets de bois, les nouvelles installations ont de meilleures chances de donner satisfaction. Cependant, ces progrès peuvent aussi faire augmenter les investissements nécessaires à la mise en place des installations.

1.1.2 Humidité dans les déchets de bois

L'énergie utile que l'on peut tirer des déchets de bois est directement proportionnelle à leur teneur en humidité. Celle-ci affecte le rendement de la chaudière à cause de la perte de chaleur latente causée par l'humidité du combustible et réduit aussi sa capacité de production à cause de la quantité d'eau qui doit être évaporée et de la vitesse à laquelle se fait l'évaporation. Le volume des chaudières et la taille des ventilateurs doivent être augmentés afin de faire face à l'augmentation du volume de gaz causée par l'humidité qui s'évapore.

La majorité des industries essaient de maintenir les taux d'humidité au plus bas en utilisant des techniques d'écorçage à sec et des procédés de dégel des billes afin d'éliminer la glace et la neige qui y adhèrent. Lorsque l'écorçage est effectué par projection d'un jet d'eau, des presses à écorce mécaniques sont utilisées pour réduire la teneur en humidité. En général, la teneur en humidité moyenne des déchets de bois sur l'année se situe entre 50% et 55 % (en poids à l'état humide) mais peut varier entre 30% et 65% en fonction des techniques de manutention et de stockage.

1.2 But de l'étude

On recommande de sécher les déchets de bois avant de les introduire dans la chambre de combustion de la chaudière comme moyen de stabiliser la combustion, d'améliorer la réponse à la charge et soit

1. Introduction

d'augmenter la capacité de combustion des déchets de bois des chaudières existantes soit de diminuer les coûts d'installation de nouvelles chaudières. Trois types d'appareils de séchage par contact direct ont été élaborés et mis à l'essai dans des usines de pâtes et papiers au Canada. La majorité de ces installations ont été financées en partie par le Gouvernement du Canada dans le cadre de ses programmes d'énergies renouvelables.

Le but de cette étude est d'examiner les résultats obtenus par l'usage de certains de ces appareils et de déterminer quels sont les problèmes de fonctionnement et d'entretien les plus sérieux qui sont survenus et quels sont leurs effets sur la rentabilité à court et long terme des systèmes. L'étude ne traite que des séchoirs utilisant les gaz de carneaux en contact direct avec les déchets de bois.

1.3 Types de séchoirs à contact direct

Trois types de séchoirs à contact direct sont utilisés au Canada: les séchoirs rotatifs, les séchoirs à cascade et les séchoirs pneumatiques. Chaque type est décrit brièvement dans les paragraphes qui suivent. On suppose que les lecteurs connaissent déjà les principes de fonctionnement de ces séchoirs de même que les principes théoriques inhérents à leur conception. Les rapports ENFOR C-96 et C-258 partie I, volume III contiennent une étude complète de ces séchoirs.

1.3.1 Séchoirs rotatifs

Ils sont composés d'un cylindre rotatif horizontal ou légèrement incliné. Les gaz de carneaux chauds et les déchets de bois humides entrent dans le cylindre à une extrémité et se déplacent vers l'autre extrémité. Des releveurs placés sur le pourtour du cylindre permettent d'agiter les déchets de bois et de les faire passer dans le courant de gaz chauds. Une partie des fines comprises dans les déchets de bois sont amenées par les gaz de carneaux dans des cyclones à l'extérieur du séchoir, où elles sont séparées des gaz.

1.3.2 Séchoirs à cascade

Les séchoirs à cascade sont composés d'un cylindre vertical comportant un cône à chaque extrémité. Les gaz de carneaux chauds entrent dans le cylindre par le bas et remontent vers le haut du cylindre et de là redescendent le long des parois

1. Introduction

extérieures. Une partie des gaz quitte le cylindre autour du déflecteur. Les déchets de bois entrent dans le cylindre par le haut, près des parois, et descendent vers le bas où ils se joignent aux gaz qui les font remonter vers le déflecteur. Une fente dans la paroi du cylindre permet à une partie des déchets de sortir. Une série de cyclones sert à séparer les fines des gaz d'échappement.

1.3.3 Séchoirs pneumatiques

Dans les séchoirs pneumatiques, les déchets de bois humides tombent dans un courant de gaz de carneaux chauds qui les transporte vers un classificateur. Ce dernier trie les grosses particules et les dirige vers un broyeur à marteaux qui les réduit en fragments pour qu'elles sèchent plus aisément et les renvoie dans le classificateur. Du classificateur, les gaz de carneaux et les déchets de bois passent par une conduite de séchage pneumatique puis par un cyclone où ils sont séparés.

1.4 Installations de séchage des déchets de bois

Il y a cinq systèmes importants de séchage des déchets de bois en fonctionnement dans les usines de pâtes et papiers du Canada. Il s'agit de trois systèmes rotatifs, d'un système à cascade et d'un système pneumatique. Les données de base pour chaque système se trouvent dans les tableaux 1 et 2 suivants.

Table No. 1

Hog Fuel Dryer Installations

in

Canadian Pulp and Paper Mills

Type of Dryer	Location	Dryer Manufacturer	Capacity	Dryer Size	Startup Year
Rotary	MacMillan Bloedel Ltd. Powell River, B.C. Fire Project MC-3	Sterns-Rogers	Two parallel systems at 26 BDMT/hr. each	Two 13'-6" Dia. x 59'	1982
Rotary	Great Lakes Forest Products Ltd. Thunder Bay, Ontario Not a Fire Project	Rader	19 BDMT/hr	14' Dia. x 30'	1983
Rotary	Scott Maritimes Ltd. New Glasgow, N.S. Fire Project S-16	Rader	15.6 BDMT/hr.	15' Dia. x 30'	1984
Cascade	British Columbia Forest Products Ltd. Crofton, B.C. Fire Project B-6	Bahco	Two parallel systems at 12 BDMT/hr. each	27'-4" Dia. x 37'	1982
Flash	E. B. Eddy Forest Products Ltd. Espanola, Ontario Fire Project E-2	Flakt	Two parallel systems at 8.7 BDMT/hr. each	Not available	1984

BDMT : Bone Dry Metric Tonnes

Table No. 2

Summary of System Performance Data

System	Capital Cost $	Design Capacity * T/hr		Operating Rate * T/hr		Fuel Moisture %		Fuel Gas Temp. °C		Add'nl Steam Gen. (1) kg/hr	No. of Boilers	Type of Firing	Type of Dust Collection
		Thru Dryer	Bypassed	Planned	Actual	In	Out	In	Out				
Rotary	8,200,000	36	Varies	32	?	57	46	195	93	10,000	1	Fixed Grate	Cyclone
Rotary	24,000,000	140	Varies	104	99	62.5	50	232	93	48,000	3	Fixed Grate	Cyclone
Rotary	----	-	-	-	-	-	-	-	-	-	-	-	-
Cascade	8,500,000	60	10	60	70	60	42	227	121	68,000	1	Travelling Grate	Multi-clone
Flash	20,600,000	35	-	32	?	50	12	280	38	91,000	1	Suspension	Precipitator

* T/hr: Tonnes/hr - as received (wet)

(1) As reported by the mills

NEILL AND GUNTER LIMITED

Hog Fuel Drying

Status of Existing Systems

in the

Canadian Pulp and Paper Industry

2. Rotary Dryers

Rotary hog fuel drying systems have been installed in three Canadian pulp and paper mills. They are located at Great Lakes Forest Products, Thunder Bay, Ont., MacMillan Bloedel Limited, Powell River, B.C. and at Scott Maritimes Limited, New Glasgow, N.S.

Visits were made to MacMillan Bloedel's Powell River mill where Stearns-Rogers dryers are installed and to Scott Maritime's New Glasgow mill where a Rader dryer is installed. Telephone contacts were made with Great Lakes Forest Products in Thunder Bay and information obtained on their Rader dryer installation.

2.1 Stearns-Rogers Dryer
MacMillan Bloedel, Powell River, B.C.

MacMillan Bloedel's, Powell River mill produces newsprint and bleached and semi-bleached kraft pulp. This mill has a total of four power boilers. Three of these boilers burn a combination of oil and hog fuel. The hog fuel moistures were high, in the range of 58 to 60 per cent moisture content, boiler efficiencies were consequently low and considerable oil firing was required to stabilize the combustion of the higher moisture hog fuel.

Sixty-five per cent of the hog fuel is purchased and contains cedar and hemlock bark and wood waste with a high sawdust content.

Two Stearns-Rogers rotary hog fuel dryers were installed in parallel and the new drying system was placed in operation in February 1982.

2.1.1 Operating Conditions

Each rotary dryer was designed to dry 26.3 Bone Dry tonnes per hour of hog fuel from 62.5 per cent to 48 per cent moisture content using boiler flue gas into the dryers at 288°C and out of the dryers at 93°C. In actual operation the inlet gas temperature ranges from 190°C to 298°C.

2.1 Stearns-Rogers/MacMillan Bloedel

The drying system has increased steam generation from hog fuel burning by an average of 48,000 kg/hr, has reduced or eliminated the use of oil firing to stabilize hog fuel combustion and has allowed the boilers to follow most mill steam load swings with hog fuel firing alone. The drying system is capable of operating at its design rate.

Recently this mill has taken the fines from the dust collectors after the dryer and is suspension burning them through a new Coen burner which has been added to the No. 8 boiler. This has produced additional load response capabilities.

2.1.2 Operating Problems

This drying system has been plagued with many operating problems which have curtailed the system performance.

(a) Fire Sensors

Rate of rise heat sensors are located over a number of the hog fuel conveying systems. These sensors activate deluge type sprinkler systems which saturate the conveyors with water and wash all of the hog fuel off belt conveyors.

The sensors have occasional nuisance trips which flood the conveyors and interrupt the hog fuel flow to the boilers. Some of the early trips in these sensors were related to electrical wiring problems in non-waterproof junction boxes. There have been no fires in the dryer system.

(b) Dust Collection System Plugs

An electrostatic precipitator was installed between the boiler and the dryer system to remove flyash and salt from the gas stream. The collected particulate is not reinjected into the boiler or into the fuel feed to the boiler.

The precipitator dust hoppers bridge over occasionally. When this occurs the precipitator and the drying system are bypassed and hog fuel firing is either reduced due to the higher moisture content or stopped altogether.

(c) Material Handling Conveyors

Numerous operating problems and upsets have been caused by plugs at conveyor transfer points and breakdowns in the hog fuel conveyors before and after the dryers. Most of these problems, such as conveyor shaft failures,

can be attributed to the inadequacy of the original conveyor designs. These problems have been compounded by high wear rates on the conveyor components that have led to a low system availability due to the breakdowns and the maintenance downtime required to upgrade the conveyors.

(d) Temperature and Hog Fuel Feed Controls

The hog fuel feed rate to each dryer is manually adjusted to control the dryer outlet temperature. The dryer hog fuel feeders are supplied by a common conveyor which overfeeds the two feeders. The excess moist fuel flows over a weigh belt and is added to the dried fuel. The weigh belt controls the wet fuel reclaimer. The weigh belts have not been reliable and it is planned to replace them.

The boiler flue gas temperature is controlled by manually adjusting dampers which bypass the boiler air heaters.

2.1.3 Maintenance Problems

This system has suffered from excessive wear and breakdowns in the material handling system and severe corrosion problems caused by high salt content in the hog fuel.

(a) Corrosion

Severe corrosion has occurred in the dryer shells, the ducting and fans after the dryers and in the dust collector cyclones.

In 1984 the dryer shells were lined with Ferralium 255, a stainless steel alloy, and the lifters were replaced with the same alloy. The dryer induced draft fans were replaced with 205 stainless steel fans in 1986 although erosion was considered to be the major cause of this problem rather than corrosion. The bottom portions of the dust collector cyclones have also been replaced with 254SMO stainless steel and the ductwork after the dryers was replaced with 2205 duplex stainless steel.

Dampers in the flue gas ducting which are used to bypass the dryers and precipitator were not gas tight and they corroded. The original dampers were replaced with air purged double seal type dampers.

Temperature sensors in the gas ducting corroded.

2.1 Stearns-Rogers/MacMillan Bloedel

(b) Conveyor Modifications and Repairs

Many of the conveyor transfer points and components required reworking. Rework included increasing shaft sizes and redesigning take-ups. Severe wear and erosion of chain conveyor troughs and chains have also increased maintenance costs and downtime for repairs and replacements. The mill has corrected many of these problems through the use of UHMW wear strips and designing modular conveyors that shorten replacement time.

(c) Precipitators

The collection plates on No. 1 precipitator warped and had to be replaced in November 1987. The reason for the warping is not known. At the same time the precipitator hoppers and screws were repaired and replaced. This latter work was considered to be normal maintenance.

2.1.4 Viability

This system has not met its original objectives due to lower than normal system availability and high maintenance costs. In 1985, which was the best year of operation, oil consumption in the hog fuel boilers was reduced by 75% of the anticipated reduction of 193,800 barrels per year with a system availability of 92%. However in the last four years, maintenance costs to correct corrosion problems in the dryers and breaching and repair of the precipitator has exceeded 40% of the original cost of the equipment. Thus the need for careful materials selection cannot be overstated. The dryers were designed for a total capacity of 52.6 bone dry tonnes per hour. However the total system is only required to operate at 35.5 bone dry tonnes per hour. Most of the major operating and maintenance problems are believed to be resolved and the system availability should return to the 1985 level.

2.2 Rader Dryer
Scott Maritimes, New Glasgow, Nova Scotia

Scott Maritimes produces bleach kraft pulp. The mill has one power boiler of the pin hole grate design. The boiler has a rating of 226,750 Kg/hr when firing Bunker "C" oil and 136,050 Kg/hr on hog fuel. Prior to the installation of the dryer, a significant quantity of auxiliary oil firing was required to support combustion of the 57% moisture content hog fuel and to meet the mill steam demand. Appproximately 75% of the hog fuel is generated in the mill woodroom and the balance is purchased from local sawmills. The hog fuel is mainly spruce and balsam fir bark and sawdust.

2.2 Rader/Scott Maritimes

A single Rader rotary hog fuel dryer was placed in operation in July, 1984. The dryer shell and internals, cold ducting and the dust collection cyclones are constructed of 304 stainless steel.

2.2.1 Operating Conditions

The rotary dryer was designed to dry 15.6 Bone Dry Tonnes per hour of hog fuel from 57% to 46% moisture content (wet basis) using boiler flue gas into the dryer at 204°C and out of the dryer at 93° C. This would produce an additional 10,000 kg/hr of steam from the boiler.

The drying system is operating at its design rate and is achieving moisture reductions of 8 to 10%. Typical dryer outlet fuel moisture is 47% in the summer and 51% in the winter. The actual flue gas temperatures are 195°C into the dryer and 93°C at the outlet. The power boiler output on hog fuel firing has increased to between 136,000 and 145,100 Kg/hour of steam at 5860 kPa.

2.2.2 Operating Problems

The drying system has operated well with an overall system availability of 95%. Minor operating problems have been related mainly to auxiliary equipment.

(a) Rotary Valve

The rotary valve which feeds hog fuel into the dryer was plugging due to oversized particles. The mill installed a disc type scalping screen in the hog fuel feed system which removed oversized material and bypassed it to the dryer discharge conveyor. The mill staff feel that a larger rotary valve with more horsepower would be desirable and that it should have an automatic reversing control to clear blockages.

(b) Fires

A number of fires were experienced in the dryer and the dried hog fuel bin. The fires were mainly related to high oxygen levels caused by leaks in the tubular air heater. The air heater was repaired and the fires have been eliminated.

(c) Material Handling Conveyors

During the initial operation, downtime resulted from flights breaking off the chain type conveyor between the dryer and the boiler. This problem has been corrected.

(d) Damper Controls

This dryer uses only a portion of the boiler flue gas. Dampers are used to regulate the flue gas flow to the

2.2 Rader/Scott Maritimes

dryer and bypass a portion of the flow to the main boiler stack. The dampers were located outside of the buildings. Problems were experienced with the damper linkages, especially during the winter months. The linkages were modified and enclosed.

2.2.3 Maintenance Problems

Maintenance costs for this system have been normal, including cost of the dryer trunnion repairs. Corrosion has not occurred to date due to the absence of salt in the hog fuel and the use of stainless steel in the original designs.

(a) Rotary Valve

The rotary valve is a high wear item and requires routine maintenance of the knives.

(b) Dryer Tires

The dryer tires are a welded steel fabrication rather than cast and they were not aligned parallel to the shell centerline of the dryer. Cracking has occurred in the connection between the tire flange and the leg to the dryer shell. This has required downtime for temporary repairs and will require more downtime for permanent repairs. Poor quality control during fabrication appears to be the cause of the cracking.

2.2.4 Viability

This system has met its original objectives and the mill staff are very pleased with the system operation. Initial minor problems have been overcome and maintenance costs are reasonable.

2.3 Rader Dryer
Great Lakes Forest Products Ltd. , Thunder Bay, Ontario

Great Lakes Forest Products produces bleached kraft pulp and newsprint and stud lumber. The mill has two power boilers which burn hog fuel and auxiliary fuel and a Copeland fluidized bed combustion unit which uses bark which is contaminated with dirt and boiler fly ash as a fuel source.

A single Rader rotary hog fuel dryer was installed in 1983.

2.3.1 Operating Conditions

The hog fuel dryer uses flue gas from the Copeland furnace to dry between 15 and 19 Bone Dry Tonnes per hour of woodroom bark and woodwastes from 38% moisture content to 23% moisture content (wet basis). The dried hog fuel is sent to one of

2.2 Rader/Great Lakes

2.3.2 Operating Problems

The mill staff reports that operating problems are few and minor with most of the problems related to auxiliary equipment.

2.3.3 Maintenance Problems

Continuing maintenance problems in this system consist of straightening and replacing flytes in the dryer and maintenance of the pneumatic conveying system between the dryer and the boiler.

2.3.4 Viability

This system is working well and appears to be meeting its original objectives. Maintenance costs are low.

NEILL AND GUNTER LIMITED

Hog Fuel Drying

Status of Existing Systems

in the

Canadian Pulp and Paper Industry

3. Cascade Dryers

The cascade drying system at British Columbia Forest Products Limited's mill in Crofton, British Columbia is the only installation of a cascade dryer in the Canadian pulp and paper industry. The Crofton mill produces bleached kraft pulp and newsprint. During the study a visit was made to the mill.

The mill has three power boilers, one of which burns hog fuel and No. 6 oil. No. 4 boiler is the largest of the power boilers. It is rated at 244,900 Kg/hr of steam from oil alone and 145,100 Kg/hr on hog fuel alone at 57 percent moisture content. The boiler is equipped with a travelling grate. Prior to the installation of the dryer system, the maximum steam output from the boiler when firing hog fuel was approximately 126,900 Kg/hr.

In 1982 two parallel Bacho cascade dryers were installed to reduce the moisture content of the hog fuel fed to No. 4 power boiler. Eighty-five percent of the hog fuel is purchased with the balance from the mill woodroom. The fuel mix is approximately:

19% cedar
56% hemlock
19% fir
6% effluent clarifier sludge

Fines can constitute up to 60% of the hog fuel. The mill is considering the installation of a separate fines suspension burner.

3.1 Operating Conditions

Each cascade drying system was designed to dry 12 bone dry tonnes per hour of hog fuel from 60 percent moisture content to 42 percent moisture using boiler flue gas at 254°C and discharging the gas at approximatley 113°C.

The system operates at or above the design capacity. The flue gas temperature to the dryers is not controlled. It enters the dryers at approximately 227°C and leaves at 121°C. The dryer outlet temperature is controlled by varying the hog fuel feed rate. The O_2

3. Cascade/B.C. Forest

content in the flue gas from the boiler was 7 to 8 percent before the dryer installation and is now about 3.5 percent. The boiler steam generation from hog fuel has been increased by up to 68,000 Kg/hr with the dryer installation.

3.2 Operating Problems

This cascade dryer installation has experienced a variety of operating problems most of which were related to inadequate design of secondary equipment.

3.2.1 Fires

The design of the dryers was based on an inlet temperature of 254°C to 260°C. To achieve this temperature, Feedwater was bypassed around the boiler economizer. During the initial operation of the dryer system, the dryer inlet temperature was observed as high as 274°C. Numerous fires occurred throughout the dryer system with the most serious being in the dust from the secondary dust collector cyclones. Air leakage at the secondary cyclone inlet contributed to this problem.

The flue gas temperature to the dryers was reduced by putting the feedwater back through the economizer. The flues gas is now approximately 227°C. The lowering of the gas temperature has virtually eliminated the fire problem.

3.2.2 Equipment Design

Several items of equipment proved to be inadequately sized or poorly designed and these deficiencies contributed to frequent breakdowns, plugging and capacity restrictions.

(a) Rotary Valves
The rotary valves which feed the hog fuel into the cascade drying chamber were subject to frequent plugging. The valves were replaced with a larger size and the plugging was eliminated. The mill plans to increase the size of the dryer outlet rotary valves as well.

(b) Dust Collector Fans
The booster fans for the fines and fly ash secondary cyclones on the dust collector did not have sufficient capacity. The fan wheels were replaced and the operation is now satisfactory. The new fan wheels were also thicker to allow for wear.

3. Cascade/B.C. Forest

(c) Material Handling Conveyors

Some components of the conveying systems for handling the hog fuel to and from the dryers were poorly designed. The conveyor drives are subject to shear pin failures as often as once per day. Chain conveyor flights are bent or broken, wear strips have separated from the conveyor trough, and conveying chains are wearing out very quickly which leads to frequent breaks.

British Columbia Forest Products has corrected many of these shortcomings; however, the deficiencies in the original designs still cause problems. Dusting at the conveyor transfer points after the dryers causes a continuing housekeeping problem.

3.3 Maintenance Problems

Maintenance of the drying system has been a significant cost item and has contributed to a reduction in the system availability. The major maintenance problems are corrosion in the drying system, wear due to abrasion and correcting conveyor deficiencies. Maintenance is scheduled every six months to repair corrosion resistant linings in the dryers.

3.3.1 Corrosion

The hog fuel supply to this drying system has a high salt content. Tests of the flue gas after the dust collectors have shown salt emissions of 0.2 Gr/SCF. The presence of salt has lead to corrosion in the cascade dryer and expansion joints. Carbon steel construction was used for all components of the system.

The majority of the corrosion has occurred in the cascade dryer. The deflector cone which was abrasion resistant plate was replaced with 904L stainless steel in 1983 and the bottom cone has been replaced with 304 stainless steel. In addition, external support points on the dryer sheet are corroding. A portion of the deterioration may be attributed to abrasion, particularly on the deflector cone. However, metal temperatures, as low as 74^{o}C have been measured on the cone. This temperature is well below the dew point of the gases and would indicate that the principle cause of failure is due to corrosion. However, erosion due to rocks hitting the dryer shell is still a problem.

Carbon steel expansion joints have been subject to localized corrosion and must be repaired on a continuing basis. The expansion joint corrosion has led to air ingress and contributed to the incidence of fires.

3. Cascade/B.C. Forest

3.3.2 Wear

The rotary valves for feeding hog fuel into and out of the cascade dryer have a continuing wear problem. These valves are changed twice yearly for major rebuilding. The mill has installed abrasion resistant liners which should extend the operating life of the valves.

The existing boiler induced draft fan was subject to severe erosion after the drying system was placed in service. The dust collectors were replaced in December 1983 with an improved design. This dramatically reduced the wear on the fan. In May 1987 a new dust separator hopper was added at the bottom of the air heater to lower the particulate loading into the dust collectors.

Conveyor rebuilds and upgrading are being carried out to overcome wear problems. Screw conveyors on the hog fuel discharge from the dryers have been replaced with 304 stainless steel troughs and stainless steel clad flights.

3.3.3 Conveyor Deficiencies

The deficiencies in the conveyor drives and other conveyor components are gradually being corrected. In some cases this has or will involve a complete replacement of the conveyor. The system availability is reaching a normal level and should continue to increase as this program is carried out.

3.4 Viability

This cascade drying system can operate at or above the original design conditions and can produce the expected benefits from increased hog fuel use in place of Bunker "C" oil. Most of the original operating and maintenance problems have been overcome and the solutions to the balance of the problems are understood.

The replacement of carbon steel components which are subject to corrosion and/or erosion with correctly selected metallurgy should provide longer life and reduced maintenance costs. Despite the operating and maintenance problems the system availability has been 85% to 90% of the boiler operating time.

NEILL AND GUNTER LIMITED

Hog Fuel Drying

Status of Existing Systems

in the

Canadian Pulp and Paper Industry

4. Flash Dryers

The single installation of a flash drying system in a Canadian Pulp and Paper mill is located at E. B. Eddy Forest Products Limited's Espanola, Ontario mill. This plant produces bleached and unbleached kraft pulp and fine and specialty papers. The Espanola mill site was not visited.

The mill had three existing power boilers[3], one of which was a 181,600 kg/hr., 1516 kPa unit, originally designed for pulverized coal burning and equipped with a dutch oven for hog fuel burning. Prior to hog fuel drying this boiler was producing up to 45,000 kg/hr. of steam from hog fuel with the balance from natural gas or Bunker "C" oil.

In 1984 two parallel Flakt flash drying systems were installed and the boiler was converted to suspension firing of dried, pulverized hog fuel. The hog fuel comes from the mill woodroom and from purchased sawmill residues.

4.1 Operating Conditions

Each flash drying system was designed to dry approximately 8.7 bone dry tonnes per hour of hog fuel from 50 percent moisture content (wet basis) to 12 percent moisture. The dryers use boiler flue gas at 220°C which is boosted to 298°C using an auxiliary gas fired burner. The dryers discharge the gas at 100°C.

Following the conversion to suspension firing of dried hog fuel, the boiler can produce up to 136,400 kg/hr. of steam from hog fuel and a 10 percent gas pilot. The boiler is also able to follow the mill steam load swings up to 136,000 kg/hr. without the use of auxiliary fuels. The drying system is operating at or above its design capacity.

4.2 Operating Problems

Several operating problems have been encountered with the system. Most of these problems have been corrected.

4. Flash/E.B. Eddy

4.2.1 Incoming Moisture Content

The dryer design was based on receiving hog fuel at 50 percent moisture content. Actual moisture contents varied up to 58 percent resulting in reduced dryer throughput. The flue gas booster heater output was increased to provide higher gas temperatures and thereby increase the water evaporation rate in the dryer. The higher gas temperatures contributed to problems with resin deposits in the dryer.

The mill subsequently improved their hog fuel storage and inventory procedures to reduce moisture gains in the fuel especially during the winter months. They also reduced to flue gas temperature to approximately 280°C.

4.2.2 Resin Buildup

Resins and fines were depositing on the dryer ductwork and on the blades of the dryer system induced draft fan. The ductwork deposits restricted air flows and the deposits on the fan blades caused balance and subsequent vibration problems in the fan. The excessive resin content was attributed to the high temperature of the drying gas, which increased the evaporation rate of the resins, overdrying of a portion of the hog fuel in the hammer mill recycle circuit, and the higher resin content of jack pine which formed a portion of the hog fuel supply.

Two measures were taken to overcome this problem. Sonic horns were installed on the fan inlet to dislodge any buildup of resin and fines and the temperature of the drying gas in the pulverizer circuit was reduced by the use of a by-pass duct.

4.2.3 Fires

Fires within the dryer system have not been a serious problem. Small fires and continuing smoldering have occured in the dry fuel bin. However, the retention time in the bin is less than 15 minutes and therefore the problem is easily controlled by running out the bin.

A number of flash fires have occurred in the ducting when inspection doors have been opened.

4.3 Maintenance Problems

Maintenance of the drying system has been relatively minor. Corrosion has not been a problem. The most significant maintenance item has been wear on the hammer mill hammers and in the discharge

duct from the hammer mill. The hammers must be replaced every three to four weeks. Flakt has been working on this problem and has improved the life of the hammers but additional life is still required.

4.4 Viability

This flash drying system is operating at or in excess of the original design criteria and all of the expected benefits are being achieved.

The initial operating problems with this drying system were not excessive and have been overcome. Maintenance costs have been reasonable for this type of equipment with the exception of the hammer mill hammers.

NEILL AND GUNTER LIMITED

Hog Fuel Drying

Status of Existing Systems

in the

Canadian Pulp and Paper Industry

5. Summary and Conclusions

5.1 Dryer Performance

All of the dryers have operated at their design capacities and achieved the expected reductions in the moisture content of the hog fuel for reasonable periods of time and have therefore demonstrated that there are no inherent design deficiencies in each of the dryers. No significant modifications or design changes were required in any of these systems in order to meet their design capacities. From this point of view each of the dryer types; rotary, cascade, and flash drying, can be considered a proven technology.

However, some of the drying systems are not achieving their design capacities on a contunuing basis due to limitations in auxilliary equipment, such as the material handling system, because of excessive downtime for major maintenance or because the boilers cannot burn additional hog fuel.

5.2 Operating Benefits

All of the mills reported that the anticipated improvements in the operation of their boilers were achieved. These consisted of increased hog fuel burning capacities, more stable combustion due to lower fuel moistures and improved load response. The effect of these improvements was substantial reductions in fossil fuel consumption at each mill.

In most of the mills, the improvements in the operation of the boilers have not produced the total fuel savings that were originally planned. Complete data on the actual fuel savings from the date of start up of the dryers was provided by two mills, partial data was provided by a third, and no data was available from the other two, although one of these provided a brief statement of performance relative to the planned operation. A comparison of the actual versus planned fossil fuel savings is summarized in Table No.3

5. Summary and Conclusions

Table No. 3

Actual Fossil Fuel Savings

As a Percentage of Planned Savings

	Mill				
	A[a]	B[b]	C	D	E[c]
Best Year	140	83.6	75.7	80.8	-
Average	-	74.6	41.0	77.8	-

a. Relative Performance
b. Incomplete Data
c. No data

A significant portion of the differences between the actual average and the planned fuel savings can be attributed to limitations in auxilliary equipment as mentioned in 5.1 above. The balance of the difference may be due to optimistic expectations of the boiler improvements or because of changes in mill operating conditions that limited hog fuel burning. In spite of these differences the mills stated that they were satisfied with the results achieved.

5.3 Operating Problems

The initial operating problems with the dryers themselves were relatively minor and could generally be considered part of the normal start-up and learning curve associated with new equipment and processes.

5.3.1 Fires

The only continuing operating problem is fires and this is common to each of the types of dryers. The incidence of fires in each case is related to high oxygen levels in the flue gas and has generally been caused by air leakages in items such as tubular air heaters, expansion joints and miscellaneous seals.

Fires are generally extinguished or controlled with little damage or downtime and are a minor problem.

5. Summary and Conclusions

5.3.2 Material Handling Systems

In some cases significant operating problems have been caused and continue to be caused by auxiliary equipment and systems related to the dryer. One of the most common deficiencies has been in the design or fabrication of the material handling systems for the hog fuel and for dust from the dust collectors.

Three of the five installations had to modify or replace components in their conveying systems and two of the mills had problems with their rotary airlock valves for hog fuel. The conveyor problems included shaft failures, drive failures, conveying chain and flight breakage and transfer point plugs. Two of the mills had plugging problems with rotary valves. One of the mills increased the size of the valve and the other removed oversized pieces of hog fuel which had been causing the plugging.

In all of the above cases, the material handling deficiencies caused downtime and reduced system availability. All of the sites have been able to correct most of the deficiencies and their system availabilities have increased to normal levels for this type of equipment. Current system availabilities for three of the mills are 95%, 85-90%, and 98%.

The conveying and processing of hog fuel and control of boiler particulates are well developed technologies and should not have presented a major technical challenge. Greater attention must be given to these aspects of future drying systems. Hog fuel is an abrasive, non-homogeneous material and therefore material handling equipment should have larger than normal design margins for drives and equipment sizing. This will account for surges, changes in bulk density, and oversize material. This equipment should be fabricated with abrasion resistant materials and the wearing parts should be designed for ease of replacement.

5.3.3 Miscellaneous

Each of the installations had miscellaneous operating problems which were caused by auxiliary equipment. Although there were some common elements, no two sites had exactly the same problem. Common problems included dust collectors and temperature sensors for flue gas and fire detection systems. All of these problems were or are relatively easy to resolve.

5. Summary and Conslusions

5.4 Maintenance Problems

The maintenance costs of the hog fuel drying systems has been a significant cost factor in two of the five installations. The costs for the other mills are considered normal. The two major cost factors are corrosion and wear in the equipment.

5.4.1 Corrosion

The two dryer installations located in British Columbia have experienced severe corrosion in the dryers, and one of those mills has had corrosion in the cold end ducting, the dust collecting cyclones after the dryers and the induced draft fan for the dryers. The hog fuel used in both of these mills contains a significant amount of salt which is the principle cause of the corrosion. Both of these dryer systems were constructed of carbon steel and have required extensive repairs or replacements which utilized a variety of stainless steels. One of these dryers is a rotary type while the other is a cascade dryer.

None of the other installations have experienced corrosion in their systems. One of these used 304 stainless steel in the original dryer, ducting and cyclone fabrication. The wood supply for these mills is not transported or stored in salt water and therefore the salt content of the hog fuel should be negligible.

It is clear from the experience of the two British Columbia mills that the materials of construction for future hog fuel drying systems must be carefully selected for the specific type and source of the hog fuel to be used. It is possible that the use of more expensive corrosion resistant materials may increase the cost of these systems beyond the point of economic viability. However, this can only be determined by detailed analysis of each specific case.

5.4.2 Wear

Each of the five mills has reported premature wearing of one or more components in their drying system. However, the extent of the problem varies considerably between the various systems.

Two of the mills consider that wearing in the rotary airlock valves used for feeding hog fuel into the dryer is higher than normal. This is unrelated to the type of dryer or the valve manufacturer.

The wear of the hammer mill used in the flash drying system is considered to be excessive and work is continuing on resolving this problem.

5. Summary and Conclusions

Two of the mills have very high maintenance costs for replacement of conveyor components such as wear strips, chains and flights and screws. A portion of these costs could be attributed to upgrading of original conveyor components to make them more wear resistant and to improve the ease of future repairs and replacements.

The nature of hog fuel varies with each mill site and therefore general statements cannot be made as to the correct solutions to the problems of wear in hog fuel processing equipment. However, the wear problems and equipment downtime that have occurred point out the need for careful analysis of the composition of the hog fuel and selection of equipment components that are best suited to the specific site conditions.

Appendix 1

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(5) Simons Resource Consultants, B.H. Levelton & Associates Ltd, "A Comparative Assessment of Forest Biomass Conversion to Energy Forms", ENFOR Project C-258, Phase I, Volume III, Energy Mines and Resources Canada, December, 1983.

Appendix 2

1. Abbreviations

BDMT	-Bone Dry Metric Tonne
gr/SCF	-Grains per Standard Cubic Foot
Kg	-Kilogram
Kg/hr	-Kilogram per hour
KPa	-Kilopascal
M.C.	-Moisture Content
^{o}C	-Degree Celsius
UHMW	-Ultra High Molecular Weight (Plastic)

2. Glossary of Terms

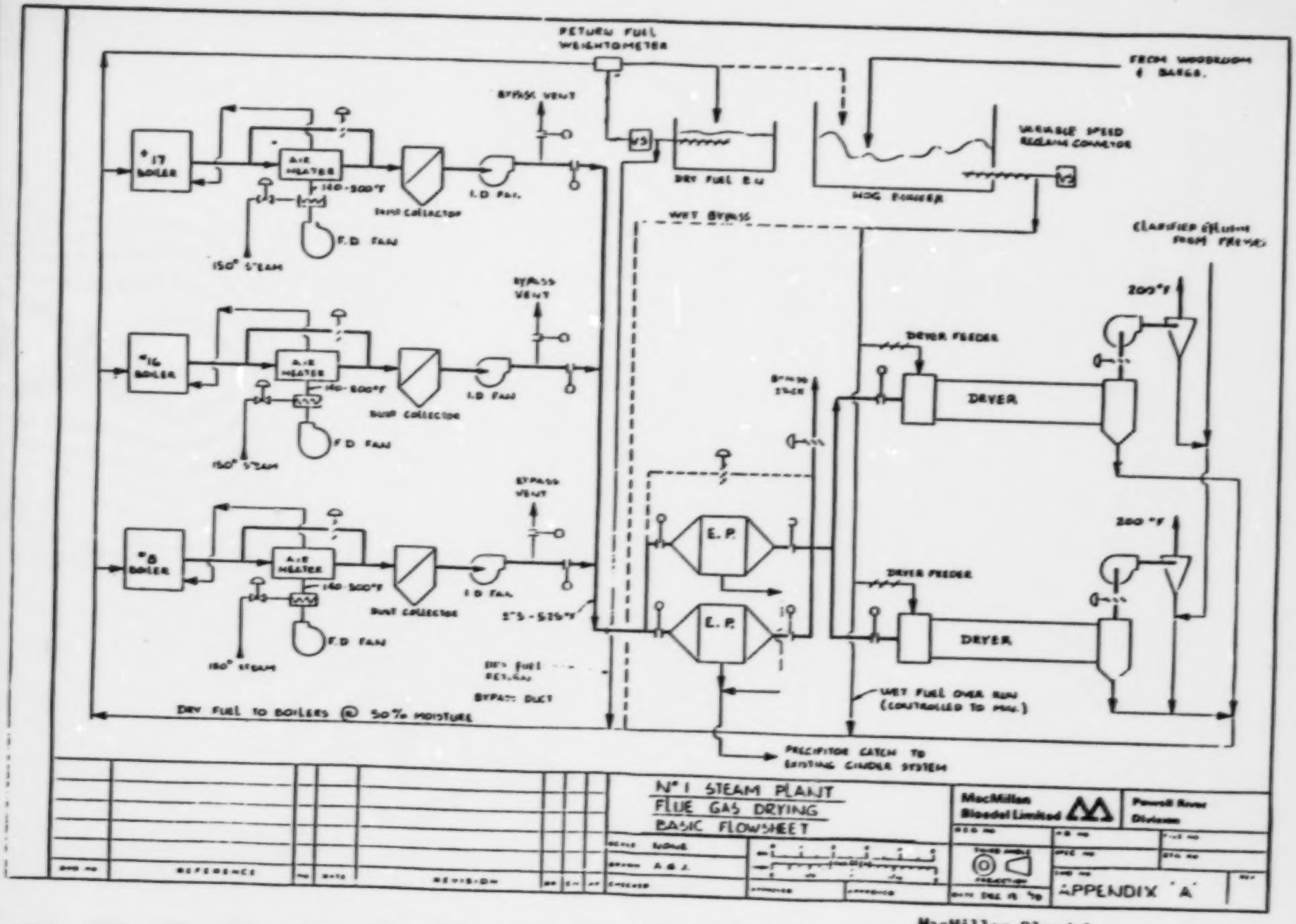
Bone Dry -Wood having zero moisture content.

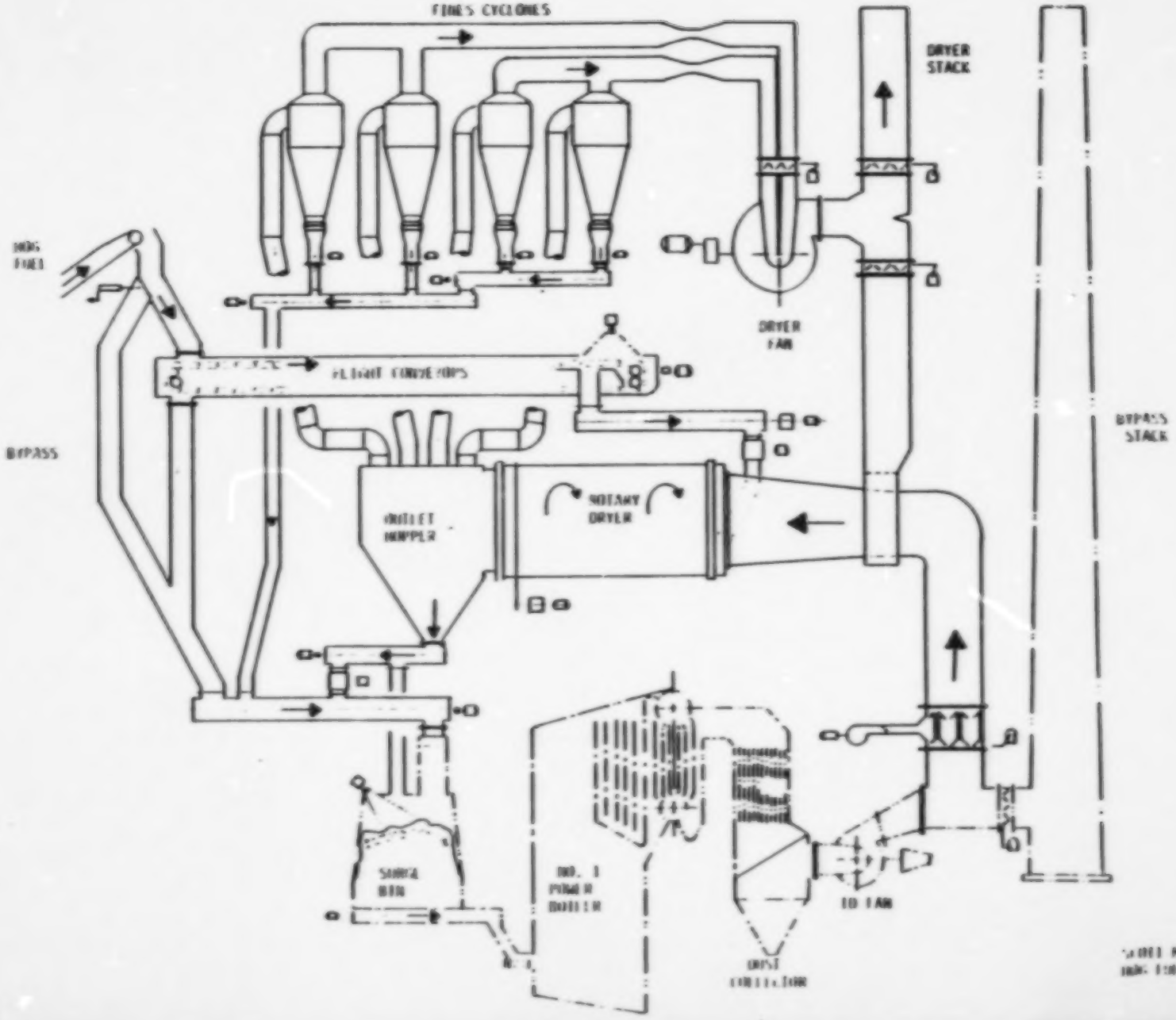
Moisture Content (M.C.) -The fraction or percentage of water in wood as determined in a laboratory drying oven and calculated on either a wet or dry basis. A wet basis moisture content is used in this report.

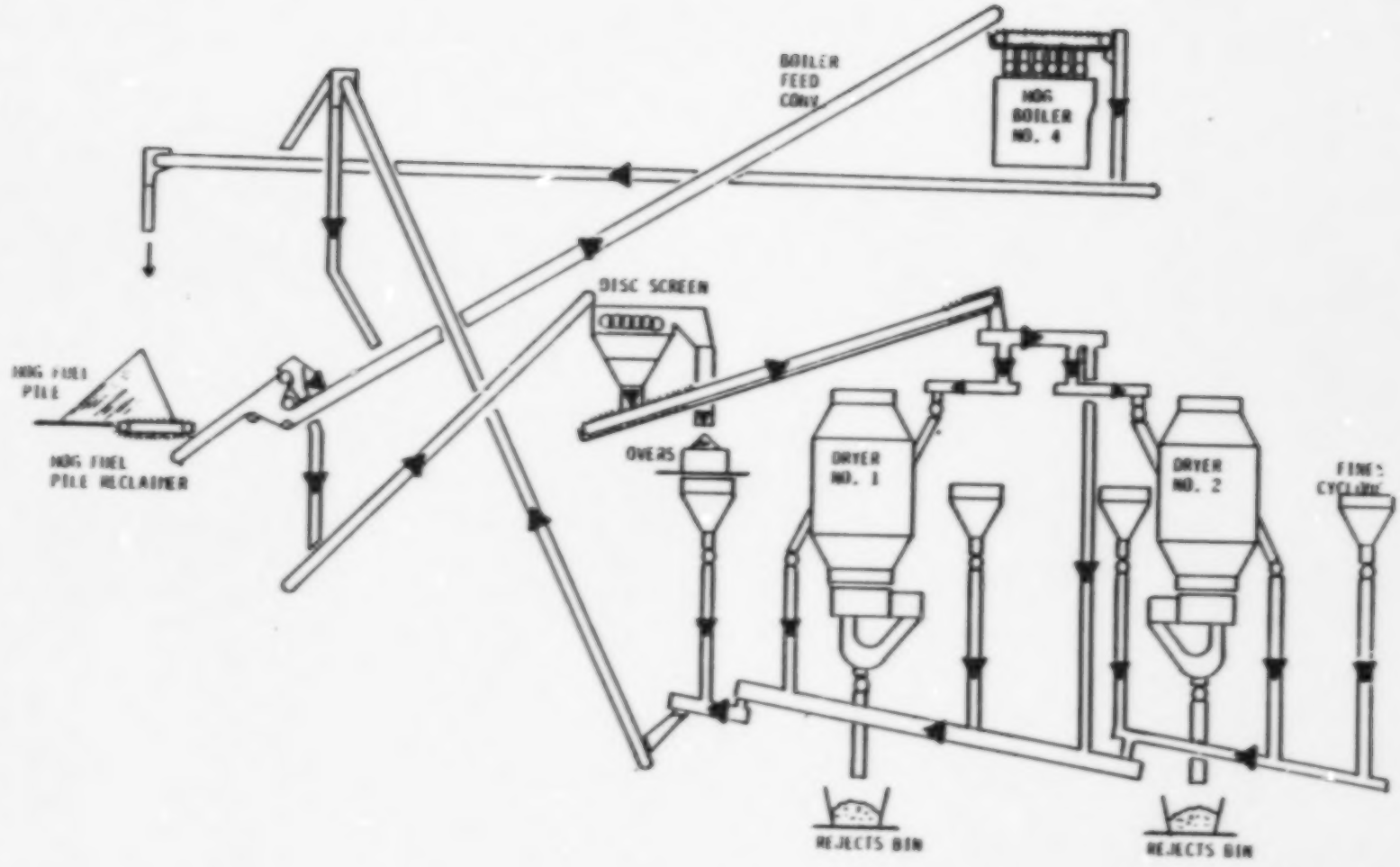
M.C. (wet basis) =

$$\frac{\text{weight of water removed in oven drying}}{\text{original weight of wood including its moisture.}}$$

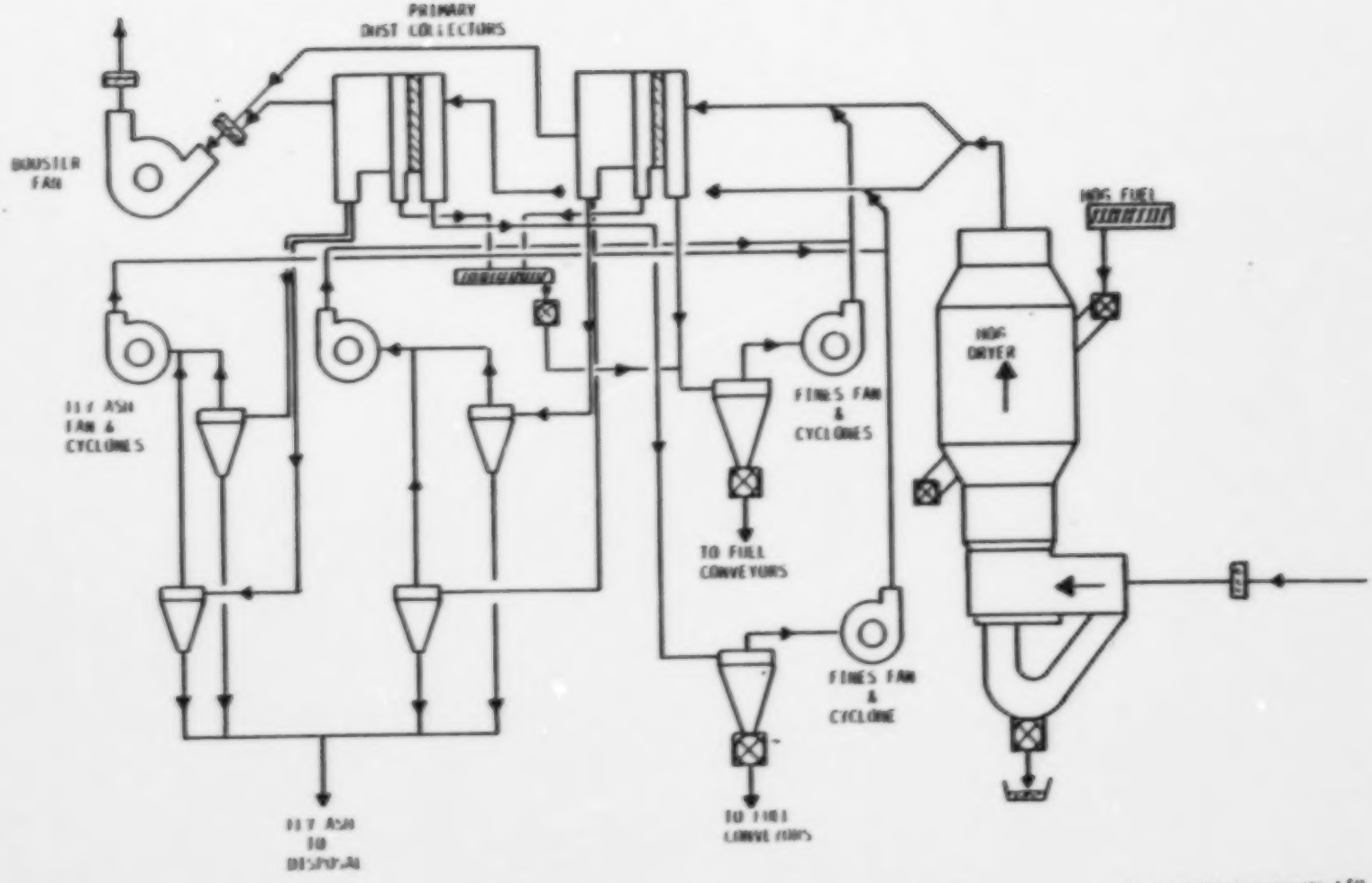
Hog Fuel -A common term referring to wood processing by-products such as bark, wood residues, sawdust, and shavings which have little or no commercial value except as a fuel.


RETURN FUEL WEIGHTOMETER
FROM WOODROOM & BARGE.
BYPASS VENT
#17 BOILER
AIR HEATER
140-500°F
DUST COLLECTOR
I.D FAN
F.D FAN
150# STEAM
V3
DRY FUEL B.U
HOG FUEL BIN
VARIABLE SPEED RECLAIM CONVEYOR
WET BYPASS
CLARIFIER EFFLUENT FROM PREVEC
#16 BOILER
BYPASS VENT
205°F
DRYER FEEDER
DRYER
#8 BOILER
E.P.
200°F
525-525°F
DRY FUEL RETURN
BYPASS DUCT
WET FUEL OVER RUN (CONTROLLED TO MAX.)
DRY FUEL TO BOILERS @ 50% MOISTURE
PRECIPITOR CATCH TO EXISTING CYCLONE SYSTEM
N°1 STEAM PLANT
FLUE GAS DRYING
BASIC FLOWSHEET
MacMillan Bloedel Limited
Powell River Division
APPENDIX 'A'


FINES CYCLONES
DRYER STACK
DRYER FAN
BYPASS STACK
BYPASS
ROTARY DRYER
SURGE BIN
ID FAN



B.C. FOREST PRODUCTS LTD.
HOG FUEL DRYING SYSTEM
SHEET 1 OF 2



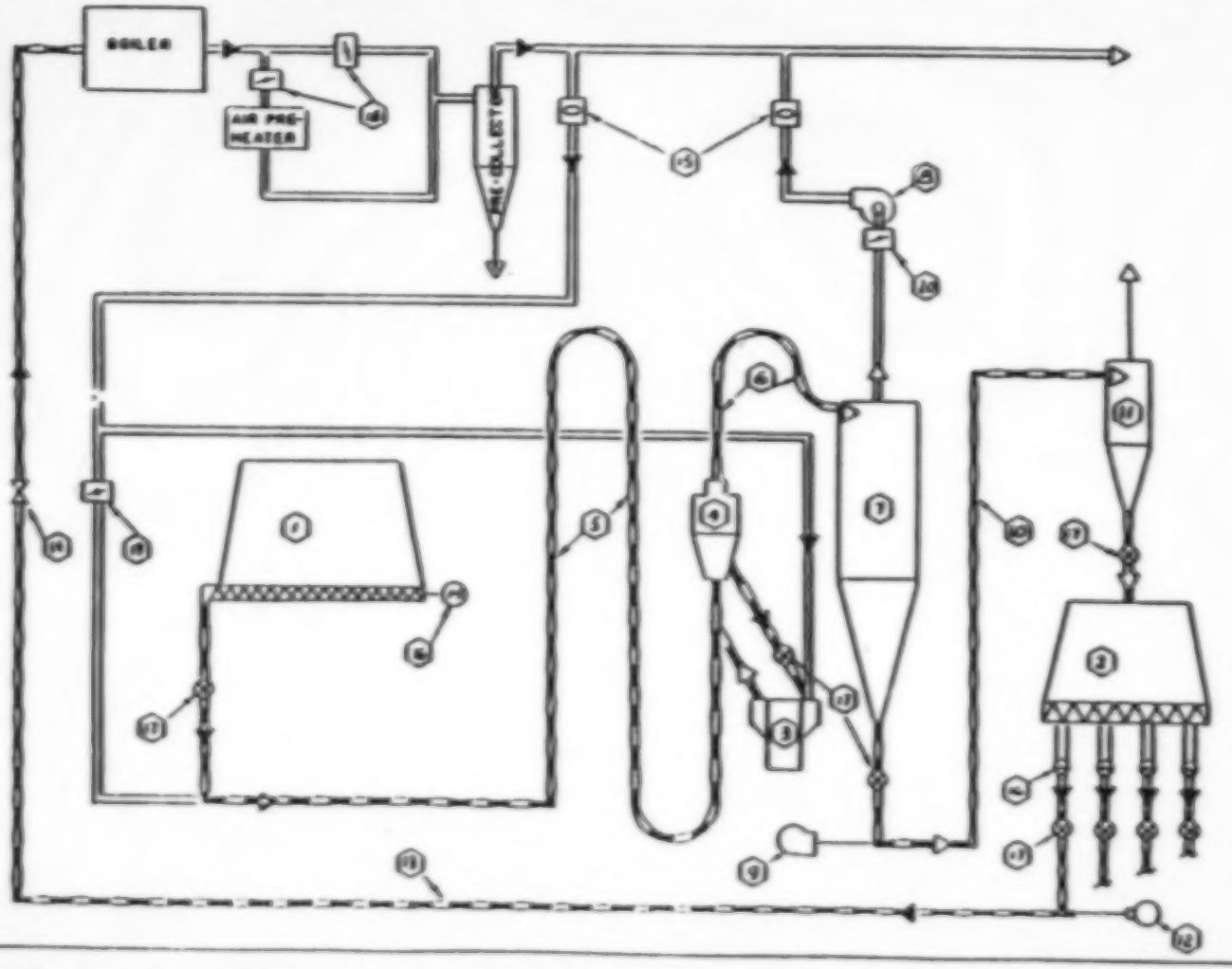
B. C. FOREST PRODUCTS LTD.
HOG FUEL DRYING SYSTEM
SHEET 2 OF 2

Flakt Canada Ltd

FLAKT BIOMASSTER

MILL DRYING SYSTEM FOR HOG FUEL

DWG NO
COB 62100



QUANTITY	ITEM	DESCRIPTION
1	20	GUIDE VANE DAMPER
1	19	BALANCING DAMPER
2	18	MODULATING CONTROL DAMPER
6	17	ROTARY AIR-LOCK FEEDERS
5	16	METERING SCREWS
2	15	GAS ISOLATION VALVES
4	14	DRY FUEL SHUT-OFF VALVES
4	13	PNEUMATIC TRANSPORT LINES
4	12	PNEUMATIC TRANSPORT BLOWERS
1	11	COOLING CYCLONE
1	10	COOLING DUCT
1	9	COOLING AIR FAN
1	8	DRYING GAS FAN
1	7	DRYING CYCLONE
1	6	MAIN DRYING TOWER
1	5	PRE-DRYING TOWER
1	4	CLASSIFIER
1	3	PULVERIZING MILL
1	2	DRY FUEL SURGE BIN
1	1	WET FUEL SURGE BIN

REPORT ON VISIT TO MB-POWELL RIVER, B. C.

Date of Visit: - 14/12/87

Persons Met:

W. Cripps	Mgr. of Energy & Steam
Lloyd Ryan	Steam Plant Chief
Neil Voss	Maintenance
Al Smith	Engineering
Frank Oliver	Maintenance
George Pickens	Mill Engineering

Proceeding

Steve Landry (N&G) and writer arrived at the mill late morning and met W. Cripps who handled us over to Lloyd, the Steam Plant chief for both steam plants.

MB had arranged a quick tour, then discussion over lunch with the mill maintenance and engineering people. A final tour of the Dryer plant which was in operation followed the discussions.

Comments

1. The Dryer Plant was down due to precipitator Hopper bridging and cleaning of the Hopper and screw conveyor was in progress.

2. Corrosion - Severe corrosion has occurred in the dryer itself and downstream ducting.

   The actual dryer shell has now been lined with "Ferralium 255 a Swedish SS alloy in 1984. Internal lifters etc. were also upgraded.

   The outlet hood from the dryer to the ID fans and ducting. Initially the ID fan was replaced in SS 205 alloy (1986). The gas flow from each ID fan discharges into six single cyclones, the bottom cones of which have all been replaced in SS 254 in the cylindrical portion of the cyclones, corrosion had occurred around the cold points i.e. where support brackets are welded to the can. Each of three cyclones discharges into a Flygt conveyor which originally discharged the collected fines into the dry feed to the Boilers.

4. At the last shutdown connections had been made to the bottom of each trough so that fines could be fed to a blow system to transport said fines to a new Fines burner just installed on #8 boiler.

   MB are experimenting with dust suppressants, currently Methol Alcohol is sprayed into the Fines Collection conveyors.

5. The main transport conveyors (flight type) under the dryer had caused major maintenance problems. The original take up arrangements were completely inadequate, thus take up "loops" were added.

   A final belt conveyor feeds the Hog fuel to the Boiler House, where it is discharged into the various spreader chutes. Overflow material is returned to the Storage Yard.

6. The actual installation was dirty with a lot of Bark Fines around. Over the preceding weekend strong winds had blown the fines around.

7. A contributing factor to the dirts condition is the Deluge system temperature switches which work on rate of temperature rise, not total temperature attained. Thus when a temperature switch alarms, all Deluge valves open and effectively all fuel is immediately washed to the lower end of the conveyor and deposited on to the ground with resulting untidy deposits. This type of switch apparently is an insurance requirement.

8. MB have no fires in the dryer system.

9. MB have replaced all dampers in the system with "Man-Tight" dampers by Bachmann with an air purge between double seals. The original dampers would not seal tight and were also subject to corrosion.

10. UHMW plastic liner material has been installed on all Chain flight conveyor wear surfaces. Wear qualities are good and results in quieter operation.

11. MB commented that the dried fuel was more abrasive than in the wet condition.

12. Conveyors had all electric drives.

13. Erosion had occurred in the target area of the cyclones.

14. ID fans had suffered from erosion with the wheel liners having been changed.

15. Substantial chain wear and breakage has occurred in flight conveyors.

16. The clarifer sludge has a lot of grit in it which is extremely erosive. The mixer was originally provided to mix the sludge with the dried fuel.

    It suffered severe erosion of the flights.

17. Water injection to control dust actually increased corrosion.

18. Sludge is the first material on to the main conveyor belt then fines (originally) then dried Hog fuel.

19. If the new fines burner is successful, then MB will look at putting the sludge through the dryer and the resulting fluffy material would hopefully be caught in the cyclones and fed to the fines burner.

20. Dried fuel accelerated erosion/corrosion in the boiler superheater. On old boilers the banks plug up more frequently (narrow spacing less than 1" clear).

21. With the dryer in service Hog fuel consumption has increased from about 600 to 800 units/day.

22. Extra maintenance more than anticipated.

23. Fuel mix and particle size distribution different since start up. More Fines.

    65% of fuel is purchased, sawmills now tend to stream runs, eg. all cedar, on all Hemlock. Whole barges of sawdust can result in plugged boiler or overloaded cyclones and emissions.

24. Carry over worse for dry fuel.

25. Sludge quantity: - approx. 90 - 120 t/day.

26. Total flue gas from boiler; 450,000 #/hr @ 450^{0}F.

27. Gas temp varies between 375 - 550^{0}F.

28. Approximate moisture of flue gas entering dryer 17%.

29. Original weigh belts for Hog fuel not reliable.

30. Gas temperature to dryers controlled manually.

31. Down Time for cleaning grates.

    #8 Boiler with 2 Dutch Ovens: - 3 hrs
    #16: - 1 hr.
    #17: - 1.75 hrs daily

32. #16 originally designed as oil fired boiler, converted to Hog in 1968

    #16 normally has 1 oil gun in service. But on days where fuel moisture is low that oil gun can be removed.

33. Clarifier sludge ash has low fusion temp and set furnace design gas exit temperature. For this reason on #8 boiler rebuild, a recovery boiler type screen was added.

34. One of the 2 precipitators has had plate buckling. (No accountable reason).

35. The precipitators were installed ahead of the dryers as a means to extract ash and carbon out of the system. This material is fed to the clarifier. Furnace bottom ash is not refed to the system.

36. The precipitator is also reasonably effective in catching NaCl particulate.

37. On dried fuel, excess air is reduced.

38. Boilers #16/17 have fixed grates, on which a fairly thick bed is carried.

39. On #8 Boiler - Typical max load on wet Hog is 175,000 #/hr, on dry Hog, max load is 250,000 #/hr.

    Generally with wet bark one oil gun would be in service, no oil is normally burned with dry bark.

    The fines burner when in service with oil pilot, generates about 50,000 #/hr. steam.

40. If sludge put through dryer, it becomes very light and fluffy which carried over to the cyclones. Also, it would be preferentially dried. (Good fuel for Fines Burner.)

41. MB has a sludge dryer which is not used when Hog dryer is in use.

42. A minor explosion occurred in one cyclone as a result of welder, welding on outside casing.

43. 85% collection of flue gas particulate upstream of dryers (By precipitator) considered reasonable.

44. Corrosion of temperature sensors is significant eg. one must specify type of thermowell material.

45. Boilers can carry load swings much better on dry fuel. (Variable speed Hog Feeder).

46. Dust leakage on pressurized precipitator presents maintenance problems.

47. NaCl @ High temps attacks gasket material, now have double doors with air purge (in precip).

48. Extra 1/2 person required for maintenance.

49. Boiler exhausted to atmosphere to avoid corrosion if oil being fired only.

50. Dryer gas out temperature; - 200°F
    Inlet moisture 62.5%
    Outlet moisture 50%

    Particulate emissions - 2060 mg/hr @ 12% O_2 (No salt)

51. Boiler efficiency and Unburnt carbon never measured.

52. MB supplied economic operating data.

53. #8 Boiler had just been rebuilt by B & W.
    Rebuild included:
    - complete furnace

- superheater
- screen
- hydro grate
- OFA fan
- 4 new oil burners (Todd)
- 1 Coen Fines Burner
- Furnace Arches
- Honeywell TDC 3000 controls
- 5 variable speed drag fuel feeders

54. At the time of our 2nd tour the Boiler was making full load, with one oil gun in service, the fines Burner was also in service. Dry Hog fuel was being fed to the grate, Bed was thin, grate was dark at the front but at the rear had the typical appearance of a Traveling grate.

    Combustion just above the Fines burner showed flame tails moving vertically up.

    At the inlet to the screen tubes, the furnace was very bright, with little sparkler carry over.

    By contrast, in the morning, with wet Hog fuel, the lower furnace was "puffing". Stoker operation 9 seconds every 300 seconds.

Conclusions

1. M & B had suffered severe corrosion problems in the dryer and downstream. Hopefully now overcome with material substitution.

2. Frequent shutdowns occur due to failure of the conveyer. System or spurious temperature alarms.

3. There is a significant increase in steam production and Hog consumption with the dryer in service.

4. Burning dryer Hog fuel significantly improves the combustion stability such that oil can be removed.

5. Too many Fines in the fuel can cause excessive stack emissions (The Fines burner may improve this situation).

6. Extra maintenance is carried out with effectively the same manpower.

VISIT TO SCOTT MARITIMES LIMITED

Date of visit: January 20, 1988

Person Met: Keith MacDonald
Jerry Mason
Tim Dickie

Observations

1. The dryer was commissioned in July 1984.

2. The dryer was part of a major upgrade with hog fuel handling involving the replacement of a blow line transport system by enclosed belt conveyors. Approximate capital cost for the total upgrade was over 8,000,000.

3. As a result of eliminating high horsepowered blowers the net increase in horsepower was not significant. The dryer system installed horsepower is approximately 2,000 hp. Electrical consumption amounts to 1200 hp.

4. The Ducon wet scrubber was installed after the dryer started up and was a non related project.

5. Average power boiler emissions reduced with the installation of the dryer.

6. Scott buys sawmill waste and utilizes softwood and hardwood waste.

7. The dryer performance compares favourable with the design, in that typical moisture reduction of 8 to 10%. Typical dryer outlet moisture is 51% in winter and 47% in summer.

8. Steam generation on direct hog is around 300,000 #/Hr to 320,000 #/hr max.

9. The grate is normally ashed out once every 24 hours, resulting in up to 1 hrs. down time per day. During this period oil is burned to sustain generation.

10. Emission objectives were 500 mg/DS cm. Testing indicated 386 mg/DS cm before the wet scrubber was installed. Comparable readings in Sept. 1986 after the Ducon wet scrubber was installed: - 56 mg/DS cm; this corresponds to 7 kg per hour of solids versus a Provincial limit of 60 kg. per hour.

11. Typical stack gas temperatures with the dryer in service is 210^{o}F with a gas entering temperature of 386^{o}F.

12. Bark flow to the dryer is manually controlled.

13. A Flue gas recirculation ability is built into the design but is not required.

14. Bark bin screws are a very high maintenance problem.

15. The "A frame" screw is also a problem, it distorts with load and can be load limiting.

16. System availability is 95%.

17. Most frequent cause of operating dowtime is pluggage.
    (a) Rotary valve pluggage - disc screens installed
    (b) ID fan vibration - water washing
    (c) ID fan wheel failed
    (d) Dryer sensors - temperature - problems - changed
    (e) Bark Bin fires

18. The scalping screens removed the oversized material and bypass it to the dryer discharge conveyer.

19. Steam smothering is used as the fire extinguishing medium.

20. Extra help - probably require 1 cleaner.

21. Cause of dryer downtime
    (a) Rotary valves
    (b) Conveyers
    (c) Fan linkages
    (d) Dryer trunnions

22. Recently cracking has been experienced in the trunnions which are fabricated rather than cast.

    It would also appear that the two "tires" are not perfectly aligned.

23. One further problem discussed is the problem of restarting the dryer if it trips full of bark. This can be a serious problem owing to the very high torque required to roll the dryer "over".

24. No corrosion problems have been experienced. Stainless steel was used extensively in the initial design.

    No. NaCl is contained in the fuel as it is not ocean transported.

25. Maintenance cost - typical number might be $60,000 per year. Future computerization will give precise numbers.

26. Retubing of the airheater significantly reduced the air infiltration and number of fires.

27. Larger motors on rotary valves desirable.

28. Examples given of oil usage for 84/87 are:
    1984 - 24.27 gallons/T pulp, production 205,542 T/yr
    1987 - 19.50 gallons/T pulp, production 232,000 T/yr

29. Dryer controls are executed and displayed through a Honeywell TDC system - which appears to work well.

30. This plant is actually installed on top of the power boiler house. Considerable stiffening of the steel structure was required.

Conclusions

1. The mill is enthusiastic about the dryer and regard it as a real money saver.

2. The dryer availability is good and there have been relatively few problems. The welding problems have only surfaced this year.

3. Operation is simple and conveyers in general have not given as many problems as other mills.

4. The installation was clean, tidy and compact.

REPORT ON VISIT TO B.C.F.P., CROFTON, B.C.

Date of Visit: 15/12/87

Persons Met: John Albertson, Chief
Gordon Loat, Assistant Chief

Proceedings

Steve Landry and writer visited this mill on the 15 December and met John Albertson and Gordon Loat.

Discussions were held with John followed by a plant tour. John made available copies of the Bahco Flow sheet.

The dryers in question are twin Bahco Cascade Stationary Dryers.

Comments

1. Problems were had intially with the rotary valves feed fuel into the dryers from plugging. The valves are changed from 24" x 30" to 24" x 36", and the problems with plugging were eliminated. The mill intends to enlarge the outlet valves eventually.

   The complete valves are changed out twice a year. The valves continually suffer from erosion. Liners have now been installed.

2. The Boiler, a FW unit was rebuilt by CE in May 1987. Modifications included:
   - Rebuilt front generating tubes
   - New platen superheater
   - New Bull Nose (none previously)
   - New low press (10") OFA system

     comprising of 16 nozzles across front and rear walls. Nozzle diameter is 8" with a concentric 4" nozzle inside. The 4" nozzle is used for low loads. Both "nozzles" used for high loads.

     -6 CE rotary feeders.

3. The boiler is base loaded thus no load swings. Steam load will be typically 238,100 - 260,800 kg/hr compared with 127,000 kg/hr on wet fuel including sawmill waste (excluding oil).

   Hog consumption is now 1000-1200 units/day. The boiler load with dry hog is 45,350 - 68,000 kg/hr greater.

4. Clarifier sludge (fibre only) normally passes through a screw press and is fed directly to the boiler infeed belt or it can be fed to the hog fuel pile and blended with the hog fuel before the dryers.

5. The pile bulldozer driver can blend mixes of fuel by preferentially feeding on to the reclaim stoker which feeds the inlet belt.

6. When sludge is fired it is preferentially fed through 2 LH spouts into the furnace.

   The boiler was originally equipped with a Joy Multiclone collector which was replaced with a Zurn collector.

7. A new separator Hopper was added at the bottom of the airheater to reduce particulate loading into ID fan (severe erosion originally).

8. Sootblower erosion has occurred when firing oil and Hog. Hopefully the new front boiler bank with wider spacing will prolong operation betweeen water washings.

9. BCFP use 9000 BTU/BDT
   1 unit - 200 CUFT
   8 1/2 BDLbs in one CUFT

10. Typical fuel mix 20% cedar
    60% hemlock
    20% fir
    sludge: 0-10% Typical 6%

    85% of fuel purchased, proportion of Fines increasing.

11. Bahco dryers operated so that Gas temp leaving is 250^{O}F.

12. Original design assumed only 70% fuel through dryer. It is now 90%.

13. Retention time in the dryer is typically about 3 secs.

14. Typically up to 60% Fines enter the discharge cyclones. Some fines up to 3/16" diameter out of cyclones.

15. The gas temp entering dryer is normally 440^{O}F, original design was 525^{O}F. Reducing Gas temp, virtually eliminated fire problems.

    Frequent Fires occurred (no major damage).

16. Problems with top sheet in air heater, cracking and distortion.

17. Expected gas wt 780,000 #/hr, not all gas necessarily goes through the dryer.

18. Gas inlet temperature to dryers controlled manually by varying bypass around economizer.

19. Typical O_2 in flue gas (before dryer installed) 7 - 8%.

20. Emissions. Meet limit of .35 Gr/SCH (law is 0.1 Gr.), however, salt content is about 0.2 Gr/SCF. Government turns blind eye to NaCl fume.

21. O_2 levels in the flue gas typically were about 7.0% now operating @ 3.5% O_2 sometimes down to 2%, then stack starts to colour.

22. Grate bars changes after 8 years.

23. CE added Bullnose.

24. In 1983 corrosion/erosion detected in dryer deflector cone. Material (CS) replaced with 904L. Metal temp. measured at 165°F (thought to be low because of impact from wet bark etc.).

    Any contact point of the dryer shell with outside eg. supports is area of corrosion. Bottom of dryer cone now replaced with stainless.

    A wear plate has been added inside under the inlet rotary valve.

    Corrosion is on going. Planned shutdown twice a year to effect maintenance patch/replace metal as required.

    Outlet screws now SS clad with troughs all in stainless.

25. Localized corrosion has occurred at expansion joints. Joints inspected every 6 months repaired as necessary to prevent air ingress, partial cause of fires.

26. Flues and ID fan all C.S.

    I.D. Fan wheel has wear plates.

27. Fly Ash from Bahco multiclones dischaged to landfill. Bahco Fines feeds to main belt.

28. Booster fans operate satisfactorily. Wheels were changed.

29. Main Bahco ID fan OK.

30. Emission from Zurn about 1.5 Gr/SCF.

31. Fires have occurred throughout system, most serious in dust from secondary cyclones due to air inlet leakage. Since reducing gas temps, no fires.

32. Thermoelectrical temp switches sensitive to radio equipment.

33. High temp alarm set to go at 500°F.

34. Secondary cyclones have thermocouples pad welded to shell.

35. Acco of Vancouver supplied all conveyors. The main problem was shear pin failures (about 1 a day) due to flexibility in drives. Only flight conveyor is for wet fuel to dryers (may be replaced), has miscellaneous problems, some flights have bent, the plastic liners have come away. Chain wear and breakage.

36. Availability approx. 85 - 90% when boiler is in service.

37. No extra people hired to operate or maintain dryer.

38. No high temp slagging in boiler.

39. A walkaround the dryer installation revealed a clean net layout.

40. The fuel as in Powell River contains a very high proportion of Fines.

41. The dryer has a reject system for oversize fuel, rejects can amount to several wheelbarrows per shift.

42. The furnace conditions at the superheater inlet were much darker (no oil) and carry over was typical of that expected.

    Grate conditions were typical for Travelling Grate.

Conclusions

1. Corrosion has been a problem but not as extensive as it Powell River (probably mitigated by raising backend gas temperature).

2. Availability is good but can be improved with greater reliability from conveyors.

3. Boiler steam generation is significantly increased with dry fuel.

4. Fires eliminated by lowering gas temps and controlling air ingress.

5. System easy to operate.

6. Clean and tidy installation.